The Fate of Arp 271

"What will become of these galaxies?"

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Figure 1: Arp 271 as taken by the Gemini Observatory and published by NASA for their Astronomy Picture of the Day; July 21, 2008.

ABSTRACT

Using data obtained from observational studies made predominantly by Fuentes-Carrera et al (2004) which constrain the masses and systemic velocities of the interacting galactic pair NGC 5426 and NGC 5427, I provide a possible scenario for the evolution of Arp 271. Using values within the limit of error for the masses and velocities of the galaxies involved I find that merging occurs and the subsequent formation of an elliptical is unavoidable. A lower limit for the relative systematic velocity required to ensure a merging of NGC 5426 and NGC 5427 does *not* occur is also provided.

Introduction

Astronomy Picture of the Day (APOD) is a NASA website which on July 21st, 2008, showed a spectacular image of Arp 271, taken by the Gemini observatory and reproduced in the top left corner of this poster (available at http://apod.nasa.gov/apod/ap080721.html.) The caption to the picture reads "*What will become of these galaxies? Spiral galaxies NGC 5426 and NGC 5427 are passing dangerously close to each other, but each is likely to survive this collision*." Likewise the European Southern Observatory (ESA) maintains a website which includes a "Picture of the Week" section. The caption to their (different) picture of Arp 271 reads, "*It is not certain that this interaction will end in a collision and ultimately a merging of the two galaxies, although the galaxies have already been affected. Together known as Arp 271, this dance will last for tens of millions of years*." (available at http://www.eso.org/public/images/potw1035a/)
The uncertainty of NASA and the ESO on this topic is the motivation for the present study.

Method

This present study uses an action-at-a-distance N-Body Galaxy Interactions code known as GalactICs (Kuijken & Dubinski, 1995) running upon the Swinburne Centre for Astrophysics and Supercomputing "Green Machine" located in Melbourne and consisting of 145 nodes each comprising of two quad-core 2.33 GHz processors, 16 GB of RAM and two 500 GB Hard Drives. Fuentes-Carrera et al (2004) used 'PUMA' - a scanning Fabry-Perot interferometer to collect this data and compared it to some earlier work by Blackman (1982). These studies provided the masses, systemic velocities and some other quantities required for the accurate simulation in this study of the interacting twin galaxies NGC 5426/27.

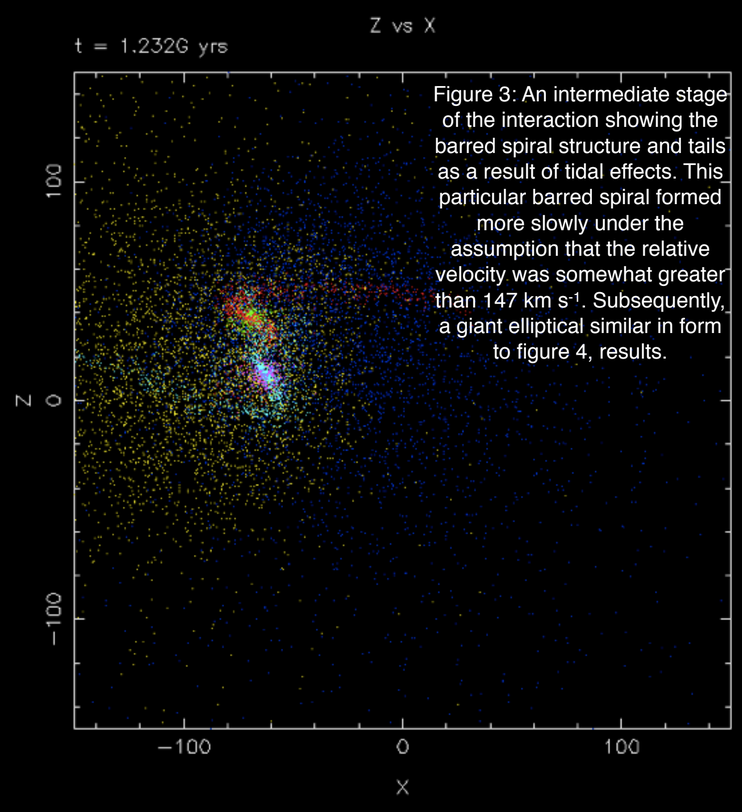

Figure 3: An intermediate stage of the interaction showing the barred spiral structure and tails as a result of tidal effects. This particular barred spiral formed more slowly under the assumption that the relative velocity was somewhat greater than 147 km s^{-1}. Subsequently, a giant elliptical similar in form to figure 4, results.

Results

The relative systemic velocity of NGC 5426 and NGC 5427 is 147 km s^{-1} and provides a reasonable lower bound upon the Kinetic Energy of the interaction. The interaction approcimates Toomre & Toomre's 'parabolic passage of an equal mass companion'. Simulations are run which commence 200 Myr before the present epoch and provide a means of testing the accuracy of the configuration. By t = 0.2 Gyr, the simulation resembles the current state of Arp 271 and there is mass flow between the galaxies. A typical initial configuration used is shown in figure 2 (below right).

I find that for a systemic velocity difference of 147 km s^{-1} merging will occur under all reasonable choices for other parameters. I find that only if the ***total*** relative velocity were to exceed approximately 515 km s^{-1} would merging not occur. Such a high velocity is not supported by observation.

For NGC 5426 and NGC 5427, the required stellar mass ratio required by Guo et al (2011) is close to 0.015 suggesting very massive halos. I find that changing the mass distribution and halo size does not affect the tendency for a merger. Parameters such as the angle of the interaction have subtle effects on the intermediate morphological stages. The rate at which the barred spiral (see figure 3, top right) forms is one example. Other tidal structures such as tails occur at intermediate stages and their time of formation is weakly affected by choice of parameters. Ultimately a giant elliptical is produced before 1.0 Gyr (figure 4, below) which extinguishes all signs of spiral structure.

Conclusions

All observational values and therefore chosen parameters - even at the absolute extremes for mass and velocity - show that NGC 5426 and NGC 5427 will eventually merge. The sequence of events leading to a giant elliptical "super galaxy" will likely produce the formation of tidal bridges and tails in a manner consistent with what Toomre and Toomre first found in 1972 for galaxies of similar mass undergoing direct parabolic passage. As shown, the merging is complete at 1.0 Gyr after our present epoch.

I can therefore provide, for the first time in the published literature an answer to NASA's Astronomy Picture of the Day question "What will become of these galaxies?" and respond that they will merge into a giant elliptical around 1.0 Gyr from now after passing through a grand-barred spiral transition. NASA also claims at the same place that "NGC 5426 and NGC 5427 are...(each) likely to survive this collision". It now seems this prediction is refuted by the computational observations of this study.

Future studies may wish to increase the number of particles and provide a higher resolution analysis of the morphology of the merging process. Although other studies are unlikely to demonstrate any deviation from the conclusion that Arp 271 is destined to merge the intermediate formation of a great barred spiral warrants further investigation.

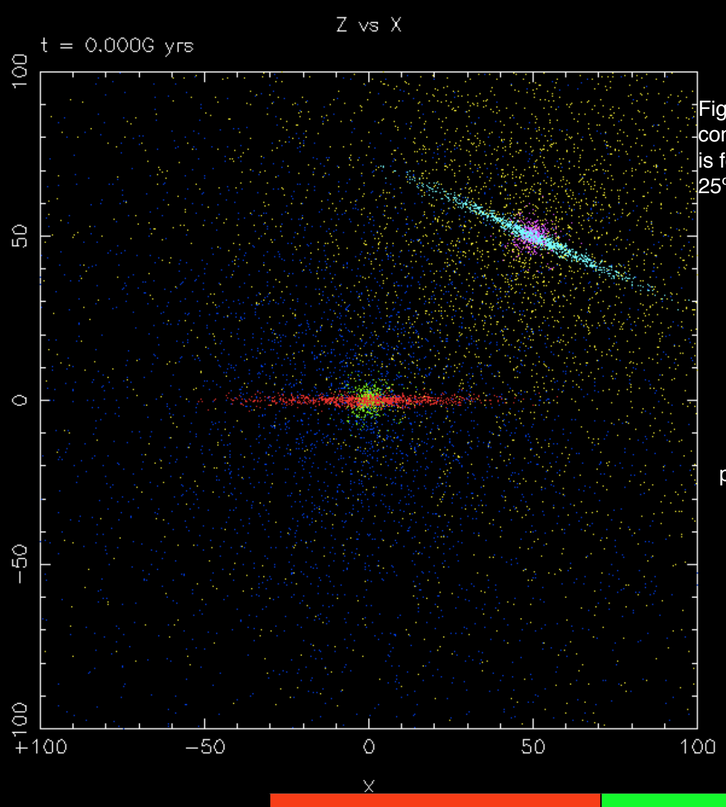

Figure 2 (left): The initial configuration in GalactICs. This is for an angle of interaction of 25°.

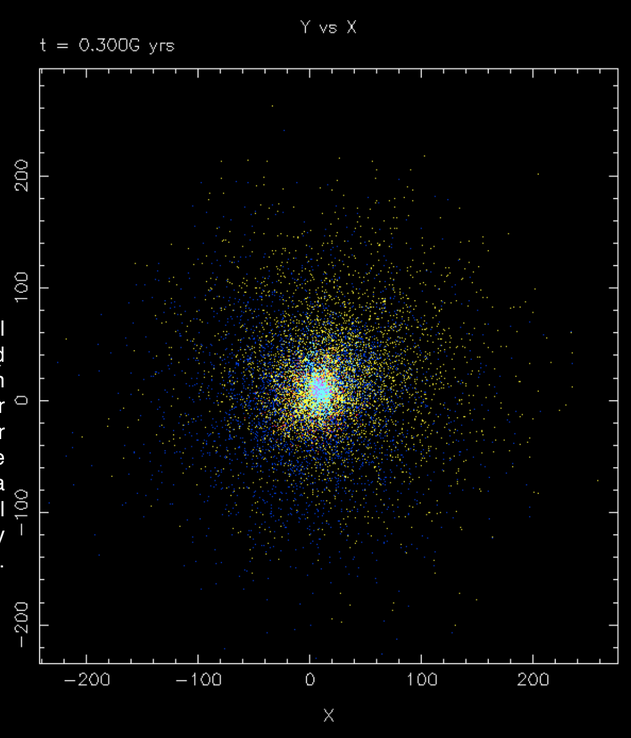

Figure 4 (right): Ultimately for all reasonable choices of the observed parameters, GalactICs in conjunction with the assumptions of this paper predicts a giant elliptical. This particular elliptical was formed quickly, under the assumption that the 147 km s^{-1} was a "significant" component of the total relative velocity as indicated by Fuentes-Carrera et al (2004).

References

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Observations of Fuentes-Carrera et al (2004)	NGC 5426	NGC 5427	Relative Value	GALACTICS INPUTS (Selection)										
				B	D	M	H	Ψ	L (6/7)	x,y,z	v(x)	Θ	5426	5427
Mass (in 10^{10} $M_\odot$)	11.2	7.5	NA											
Systemic Velocity (km s^{-1})	2575 ± 3	2722.5 ± 1	147.5 ± 4	500	1000	0.6	5000	-5.6	2.45/2	100	-147	25	1.12	0.75
Angle Of Inclination	(59 ± 3)°	(34 ± 2)°	(25 ± 5)°	500	2000	0.6	3000	-5.0	**1.2**	17.5	-147	25	1.12	0.75
KEY: B = Bulge Particles, D = Disc Particles M = Disc Mass Factor, H = Halo Particles Ψ = Halo potential well depth L = Length Scale (of NGC542**6**/NGC542**7** respectively) units of 4.5 kpc				500	1000	0.6	**5000**	-5.6	2.45/2	50	-147	**19**	1.12	0.75
				500	1000	0.6	5000	-5.6	2.45/2	50	-147	**31**	1.12	0.75
				500	1000	0.6	5000	-4.8	2.45/2	50	-147	25	0.39	0.31